

# REPORT DOCUMENTATION PAGE

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**TITLE OF PROJECT:**

Waveguide Controls on Regional Waves

**Grant #:**

F49620-95-1-0461

**Principal Investigator:**

Thorne Lay  
Institute of Tectonics and W. M. Keck Seismological Lab  
Earth Science Department  
Earth and Marine Science Building  
University of California  
Santa Cruz, CA 95064

Final Report of 20 May 2000

Reporting period 1 July 1995 to 30 June 1998

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# **Waveguide Controls on Regional Waves**

## **2. Objectives**

This project was a three-year effort (1 July, 1995 to 30 June, 1998) focussed on the fundamental problem of using short-period regional seismic signals to discriminate small nuclear explosions from earthquakes or large quarry blasts. This is an AASERT grant, which added one graduate student, Kris Eckhardt, to an ongoing funded study by AFOSR (at the outset, the "master" grant was F49620-94-1-0247, "Calibration of Regional Wave Discriminants in Diverse Geological Environments: Topographic Correlations", which concluded on 30 Apr 1997; and their was a subsequent "master" grant, F19628-95-K-0014, "Crustal Waveguide Effects on Regional Phases in China and Southeast Asia", which completed on 11 Nov. 1997. One of the first-order challenges associated with non-proliferation monitoring is to understand short-period seismic wave energy partitioning for different sources in diverse geological environments, many of which have no prior nuclear explosion history. We have developed a promising new approach of empirical calibration of regional phase energy partitioning based on relationships with readily observable surface topographic characteristics. Analysis of nuclear test recordings in the former Soviet Union under prior ARPA and AFOSR sponsored contracts revealed very strong correlations between surface topographic roughness and/or average elevation with energy partitioning in Pn, Sn and Lg phases at regional and upper mantle distances. Surface topography appears to provide, at least over many Eurasian paths, a surface observable tracking gross variations in the waveguide properties that control regional phases. Significant reduction in the scatter of measurements such as Pn/Lg or Sn/Lg can be achieved by empirical correction for path topography. Reduced scatter in such discriminant measures offers the possibility of enhanced discriminant and yield estimation performance for non-proliferation applications. Analysis of additional explosion and earthquake data sets in Eurasia, as well as earthquake data sets in the Western United States, and Middle East is being undertaken to establish whether surface topographic corrections are generally useful for regional phase analysis will be undertaken. Simultaneously, we will perform numerical investigations of the effects of surface topography on regional phase energy partitioning to lead to a quantitative understanding of the strong empirical relations that we have discovered.

## **3. Status of Effort**

The research of the master and AASERT grants has all been completed, and is published in reports and papers. This master AFOSR projects proceeded very well, and this AASERT funding added third year graduate student Kristine Eckhardt to the research project. She participated in the data processing that demonstrated that topography can be used to reduce the variance in regional discriminants, to almost the same extent that distance corrections can. This was demonstrated using a high quality data set for earthquakes in the western United States and Eurasia. Some progress was made in modeling the empirical results, however, it is still beyond current modeling techniques to fully validate the waveguide controls.

## **4. Statement of Accomplishments/Pending Work**

The budget period for this project was 36 months, initiating July 1, 1995. Kris was a Graduate Research Associate during this time, and she participated in data collection and preliminary data processing for the main effort in the master grants, which was followed through by postdoctoral researchers Guangwei Fan and Arthur Rodgers. In 1999, Kris completed her Ph.D. thesis in Seismology at UCSC, and she is now teaching at Idylwild Academy.

## **5. Personnel Supported**

P.I.: Thorne Lay, Professor of Earth Sciences  
Graduate Student Kristine Eckhardt

## **6. Publications**

Related reports that benefitted from this AASERT support are attached. These include citations for about 8 publications related to this combined research program.

## **7. Interactions/Transitions**

### *a. Presentations.*

None

### *b. Consultative and Advisory Functions*

T. Lay served on the AFTAC Seismological Review Panel, with 3 meetings each year, during the grant, along with serving on two subsequent DOE/DSWA, DTRA Review Panels..

T. Lay chaired a Panel of the National Research Council addressing the topic of "Seismological Research Requirements of a Comprehensive Test Ban Treaty". In addition to organizing 4 meetings of the panel, T. Lay was the lead author on the Panel final report, which played a significant role in CTBT discussion and research program planning.

### *c. Transitions*

Our work inspired extensive research by ENSCO, LANL and LLNL in the analysis of empirical methods to reduce scatter in regional seismic discriminants.

## **8. New Discoveries, inventions or patent disclosures.**

No inventions or patents. Our seismological analysis discovered new features of the behavior of regional phases in the complex crustal waveguide.

## **9. Honors Awards**

None.